

Application No.: 09/781,125
Amendment Dated January 9, 2004
Response to Office Action Date

Attorney Docket No.: F069

Amendments to the Claims

This listing of claims will replace all prior versions and listing of claims in the application:

Listing of Claims

1. (cancelled) An apparatus including multiple ion guns and multiple associated ion optical columns for focused ion beam processing of materials or imaging, comprising:

- one or more sealable ion gun chambers;
- one or more ion guns positioned within each of the one or more ion gun chambers, each ion gun capable of generating an ion beam;
- multiple ion optical columns, each ion optical column being associated with one of the multiple ion guns for focusing and directing the corresponding ion beam toward a target;
- a primary vacuum chamber for containing a target for processing or imaging;
- a vacuum valve associated with each of the ion guns, the vacuum valves selectively opening to allow the corresponding ion beam to pass from the associated ion gun to the target or selectively closing to seal the corresponding ion gun chamber.

2. (currently amended) The ~~An~~ apparatus of claim 1 including multiple ion guns and multiple associated ion optical columns for focused ion beam processing of materials or imaging, comprising:

- a single-sealable ion gun chamber having positioned therein multiple ion guns, each ion gun capable of generating an ion beam;
- multiple ion optical columns, each ion optical column being associated with one of the multiple ion guns for focusing and directing the corresponding ion beam toward a target;

Application No.: 09/781,125
Amendment Dated January 9, 2004
Response to Office Action Date

Attorney Docket No.: F069

a primary vacuum chamber for containing a target for processing or imaging; and
a vacuum valve associated with each of the ion guns, the vacuum valves selectively
opening to allow the corresponding ion beam to pass from the associated ion gun to the target or
selectively closing to seal the corresponding ion gun chamber.

3. (currently amended) An ~~The~~ apparatus of claim 1 including multiple ion guns and
multiple associated ion optical columns for focused ion beam processing of materials or imaging,
comprising

multiple sealable ion gun chambers each including one or more ion guns, each ion gun
capable of generating an ion beam;

multiple ion optical columns, each ion optical column being associated with one of the
multiple ion guns for focusing and directing the corresponding ion beam toward a target;

a primary vacuum chamber for containing a target for processing or imaging
a vacuum valve associated with each of the ion guns, the vacuum valves selectively
opening to allow the corresponding ion beam to pass from the associated ion gun to the target or
selectively closing to seal the corresponding ion gun chamber

4. (currently amended) The apparatus of claims 1-3 in which each sealable gun
chamber includes a vacuum pump.

5. (currently amended) The apparatus of claim 1-3 in which the vacuum valves
associated with the ion guns in each of the one or more multiple gun chambers are connected so
that the vacuum valves in each gun chamber open and close using a single control.

6. (currently amended) The apparatus of claim 1-2 in which each of the ion optical
columns includes a deceleration lens element maintained near ground potential.

Application No.: 09/781,125
Amendment Dated January 9, 2004
Response to Office Action Date

Attorney Docket No.: F069

7. (currently amended) The apparatus of claim ~~1~~ 2, in which each of the ion optical columns includes optical elements and in which corresponding ones of at least one of the optical elements in different ones of the ion optical columns ~~within a single~~ the sealable gun chamber comprise an optical element bar to provide a common voltage to corresponding optical elements within the gun chamber.

8. (original) The apparatus of claim 7, in which electrically isolated lens elements are placed in the optical element bar to allow independent control of some of the optical elements comprising the optical element bar.

9. (currently amended) The apparatus of claim ~~4~~ 2, in which the ion optical ~~column~~ columns includes multiple lens elements and further comprising means for collecting secondary particles through at least one of the lens elements for imaging or characterizing the target.

10. (previously presented) The apparatus of claim 9, in which at least one of the ion optical column further includes a deflector for deflecting secondary particles out of the path of the ion beam and in which the ion optical column includes at least one lens element between the deflector and the target, the lens element electrically biased relative to the target to create an electrical field to accelerate the charged secondary particles up through and past the lens element for detection.

11. (previously presented) The apparatus of claim 9, in which the target is biased to the same polarity as that of the charge on the secondary charged particles to accelerate the charged particles up through and past the lens and electrostatic deflector for detection.

12. (currently amended) The apparatus of claim 9, further comprising means for detecting charged secondary particles where the detector of charged particles is a channel plate multiplier

Application No.: 09/781,125
Amendment Dated January 9, 2004
Response to Office Action Date

Attorney Docket No.: F069

or scintillator detector placed substantially perpendicular to the primary beam with a center hole for the primary beam to pass through.

13. (previously presented) The apparatus of claim 9 further comprising a magnetic deflector, a Wien filter or an electrostatic deflection device for deflecting the secondary particles away from the ion beam path for collection.

14. (original) The apparatus in claim 9, further comprising a mass spectrometer for Secondary Ion Mass Spectrometry for detecting and characterizing the secondary charged particles.

15. (currently amended) The apparatus of claim ~~1~~2 in which at least some of the ion guns and ion optical columns are tilted at an angle of about three degrees to a normal to the sample surface.

16. (original) The apparatus of claim 15 in which the ion guns in a first one of the multiple ion beam gun chamber are tilted at an angle of about three degrees in a first direction from a normal to the sample surface and in which the ion guns in a second one of the multiple ion beam gun chamber are tilted at an angle of about three degrees from a normal to the sample surface in a direction opposite to the first direction.

17. (currently amended) The apparatus of claim ~~1~~2 in which each of the ion optical columns includes beam offset, scanning, steering and stigmation controls and in which the beam offset, scanning, steering and stigmation can be controlled independently for each column.

18. (currently amended) The apparatus of claim ~~1~~2 further comprising a high voltage supply for providing a high voltage to corresponding optical elements in multiple ones of the ion optical columns.

Application No.: 09/781,125
Amendment Dated January 9, 2004
Response to Office Action Date

Attorney Docket No.: F069

19. (original) The apparatus of claim 18 further comprising means for adjusting the voltage in one of the ion optical columns to deviate from the high voltage provided by the high voltage power supply.

20. (currently amended) A multiple column focused ion beam system comprising:
multiple ion guns ~~beam sources~~ for forming multiple ion beams;
a bar having holes for forming therein multiple ion optical lenses, each ion optical lens corresponding to one of the multiple ion beam sources, each ion beam source and ion optical lens forming part of an ion beam optical column; and

a power supply for applying a voltage to lenses corresponding to the bar, thereby applying a common voltage to ion optical lenses in different optical columns.

21. (original) The apparatus of claim 20 in which the bar comprises a flat conductive bar and in which the power supply provides a voltage directly to the conductive bar, the holes in the conductive bar functioning as ion optical lenses.

22. (original) The apparatus of claim 20 in which the bar comprises a flat conductive bar having electrically isolated lenses formed therein and in which the power supply provides a common voltage to all lenses in the bar and selectively provides a second voltage to individual lenses in the bar.

23. (original) The apparatus of claim 20 in which the bar comprises a flat non-conductive bar having electrically isolated lenses formed therein and in which the power supply provides a common voltage to all lenses in the bar and selectively provides second voltages to individual lenses in the bar.

Application No.: 09/781,125
Amendment Dated January 9, 2004
Response to Office Action Date

Attorney Docket No.: F069

24. (previously presented) The apparatus of claim 20 further comprising means for collecting through the lenses secondary particles emitted from the target, the secondary particles being used to image or to characterize the target.

25. (original) The apparatus in claim 23 in which individual emitters are restarted by biasing either the extractor with respect to the emitter/ suppressor elements about -2000 V, or by biasing the emitter/ suppressor elements with respect to the extractor element about 2000 V, in the individual guns as needed.

26. (canceled) The apparatus of claim 1, further comprising two or more ion guns positioned within the one or more ion gun chambers, each ion gun capable of generating an ion beam.

27. (canceled) The apparatus of claim 1, further comprising multiple ion sources, each ion source associated with one of the multiple ion guns.

28. (currently amended) The apparatus of claim 1 wherein at least one said ion beam is generated employing a liquid metal ion source.

29. (canceled) The apparatus of claim 28 wherein said liquid metal comprises gallium.

30. (previously resented) The apparatus of claim 9, in which said multiple lens elements includes an electrostatic final lens for focusing the ion beam onto the target and further comprising a means for collecting secondary particles emitted from the target and traveling through said electrostatic lens for imaging or characterizing the target.

31. (new) The apparatus of claim 3, in which the ion optical column includes multiple lens elements and further comprising means for collecting secondary particles through at least one of the lens elements for imaging or characterizing the target.

Application No.: 09/781,125
Amendment Dated January 9, 2004
Response to Office Action Date

Attorney Docket No.: F069

32. (new) The apparatus of claim 3 in which each of the ion optical columns includes beam offset, scanning, steering and stigmatization controls and in which the beam offset, scanning, steering and stigmatization can be controlled independently for each column.

33. (new) The apparatus of claim 3 further comprising a high voltage supply for providing a high voltage to corresponding optical elements in multiple ones of the ion optical columns.

34. (new) The apparatus of claim 3 wherein at least one said ion beam is generated employing a liquid metal ion source.